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# Supplementary Materials for

## The 2022 Hunga-Tonga megatsunami: Near-field simulation of a once-in-a-century event

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**The PDF file includes:**

Fig. S1
Table S1
Legends for movie S1 and S2

**Other Supplementary Material for this manuscript includes the following:**

Movies S1 and S2

# 1 Supplementary Materials (Online Only)

## 1.1 Supplementary Figure

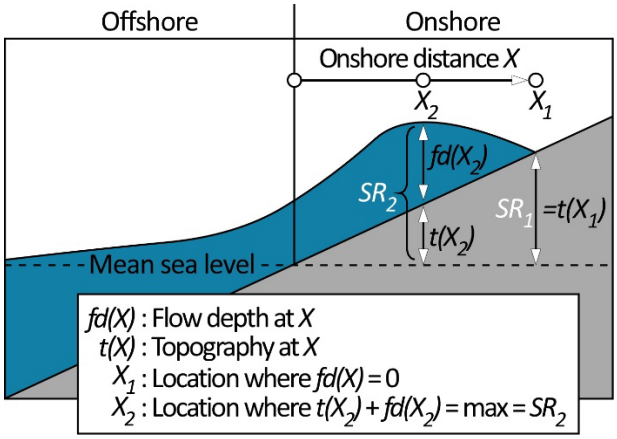


**Figure S1. Field measurement of the range of wave runup heights.** Topography *t(X)* is defined as the elevation of the land onshore or offshore relative to sea level. Flow depth *fd(X)* is the maximum flow thickness onshore, or the maximum vertical excursion of the water surface from sea level offshore. $SR_1$ denotes the height of topography above sea level where flow depth goes to zero. In the field, this point would be recognized as the highest elevation of felled or damaged vegetation and/or deposition of erratic deposits. $SR_2$ is the maximum of topography plus flow depth anywhere on land from the beach to where *fd(X)* goes to zero. $SR_2$ would be recognized by flotsam deposited by the tsunami wave in tree branches. Note that $SR_1$ and $SR_2$ do not necessarily exist in all localities. If both do exist, $SR_2$ may, or may not, exceed $SR_1$.

## 1.2 Supplementary Table

**Table S1. Tsunami Efficiency versus Blast Energy.** Note that only a small fraction of blast energy goes into tsunami waves. In this case, larger blasts are slightly less efficient than small blasts probably due to "bottoming out" effects (see Fig. 9). (1 Mt = $4.18\times10^{15}$ J).

| Blast Number | Yield W (Mt) | Blast Energy $E_w$(J) | Tsunami Energy $E_T$(J) | $E_T/Ew$ |
|---|---|---|---|---|
| 3 | 0.5 | $2.09\times10^{15}$ | $1.55\times10^{14}$ | 7.4% |
| 4 | 4.0 | $1.67\times10^{16}$ | $9.57\times10^{14}$ | 5.7% |
| 5 | 15.0 | $6.27\times10^{16}$ | $3.09\times10^{15}$ | 4.9% |

## 1.3 Supplementary Animations

Animations of the wave simulation created using the Tsunami Squares method.

**SUPPLEMENTARY ANIMATION S1 – (*S1-TS-Simulation-Pacific.mov*)** Shows the simulation at the scale of the entire Pacific with runup heights in units of centimeters. Note how the pressure-coupled tsunami driven by acoustic gravity (AG) waves outpaces the conventional tsunami. The AG-coupled water waves are simulated to be <8 cm high as they impact the Pacific rim and <5 cm high in the Caribbean (atmospheric pressure waves

can run over land and thus create waves in isolated bodies of water where the conventional tsunami cannot reach). By contrast, the conventional tsunami waves average 30 cm height at the Pacific rim.

**SUPPLEMENTARY ANIMATION S2 – (*S3-TS-Simulation-Tonga.mov*)** Animates the tsunami propagation across the Tonga archipelago. Here, wave runup heights are in units of meters. Three separate explosions at the Hunga Tonga-Hunga Ha'apai (HTHH) volcano were tsunamigenic, but it was the last one, occurring at 4:56 UTC with a yield of 15 Mt, that delivered megatsunami size waves. Panels on right-hand side show wave height along two orthogonal transects through the simulation as a function of time (denoted by broken red lines in the simulation). The panel in the bottom right animates water levels at the tide gauges located at the Queen Salote Wharf (QSW) (magenta line) and Vuna Wharf (blue line) as a function of time, versus the actual gauge records at those locations (black and red lines, respectively). Both tide gauges are situated in the port of the main city of Nuku‘alofa.